

**MONTHLY PROGRESS REPORT
MONTANA DOT "PERFORMANCE PREDICTION MODELS"
APRIL & MAY 2003**

To: Susan Sillick, MDT
Jon Watson, MDT
Agency: Fugro-BRE, Inc.
MDT Contract No.: HWY-30604-DT
Performance Period: April & May 2003
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CURRENT MONTH WORK ACTIVITIES AND COMPLETED TASKS

PHASE I

Task 1 – Literature Review

Complete. A draft memorandum summarizing the models to be considered within this project was submitted to the Montana DOT (MDT) in October 2001. This memorandum will be updated when the calibration and validation of the 2002 Design Guide distress prediction models are made available.

Task 2 – Review of MT DOT Pavement-Related Data

Complete. However, Fugro-BRE will continue to monitor the LTPP database and update any missing data on the test sections with time.

Task 3 – Establish the Experimental Factorials

Complete.

Task 4 – Develop Work Plan for Monitoring and Testing

Complete. The long-term monitoring plan will be revised after the initial analyses of the data are complete under Tasks 6 and 7.

PHASE II

Task 5 – Presentation of Work Plan to MDT

Complete.

Task 6 – Implement Work Plan – Data Collection

On-going activities. For the 10 sites initially selected (Condon, Deerlodge/Beckhill, Silver City, Roundup, Lavina, Wolf Point, Ft. Belknap, Perma, Geyser, Hammond), all testing has been completed with the exception of a few of the CTB samples. Of the four Superpave sites for which materials have recently been received, Lothair, and Baum Rd. have tentatively been

selected for inclusion in the testing program. However, testing for these two sites will begin after completion of tests on the first 10 sites.

Unbound Materials: Base/Subbase and Subgrade (Subcontractor – Fugro-South, Houston, TX):

Unbound materials from the 10 sites selected in the experimental factorial (Condon, Deerlodge, Fort Belknap, Geyser, Hammond, Lavina, Perma, Roundup, Silver City, and Wolf Point) have been tested at the Fugro-South laboratory in Houston, Texas. Moisture-density curves at modified compactive effort (AASHTO T180) were derived for each of the 17 materials prior to testing. The optimum moisture content and maximum dry density obtained for each material is given in Table 6-1.

Table 6-1. Optimum Moisture Content and Maximum Dry Density for Montana Unbound Materials (Modified Compactive Effort)

Material	Optimum w%	Max. Dry Density (pcf)
Condon_Base	7.5	136.0
Condon_Subgrade	6.0	143.5
Deerlodge_Base	5.5	146.0
Deerlodge_Subgrade	7.5	134.0
Ft Belknap_Base	7.0	136.2
Ft Belknap_Subgrade	7.5	134.0
Geyser_Base	6.5	140.5
Geyser_Subgrade	9.5	127.0
Hammond_Base	12.4	125.8
Hammond_Subgrade	13.0	117.0
Lavina_Subgrade	10.0	127.0
Perma_Base	9.5	130.5
Perma_Subgrade	9.5	129.5
Roundup_Subgrade	16.5	118.0
Silver City_Base	6.0	141.5
Silver City_Subgrade	12.5	120.5
Wolf Pt_Subgrade	14.0	117.0

A repeated load resilient modulus test was performed for each material at optimum moisture content and maximum dry density (modified). The results of the regression analysis including the number of data points n , values of the k_i regression constants and goodness of fit statistics R^2 are presented in Table 6-2. The model used to fit the test data is the 2002 Design Guide model for stress-dependent resilient modulus, and is given in Equation 6-1:

$$M_R = k_1 \cdot p_a \cdot \left(\frac{\theta}{p_a} \right)^{k_2} \cdot \left(\frac{\tau_{oct}}{p_a} + 1 \right)^{k_3} \quad (6-1)$$

Where:

M_R = Resilient Modulus in units consistent with p_a (atmospheric pressure),
 θ and τ_{oct}
 k_1, k_2, k_3 = Regression constants

θ = Bulk stress:

$$\theta = \sigma_1 + \sigma_2 + \sigma_3 \quad (6-2)$$

τ_{oct} = Octahedral shear stress:

$$\tau_{oct} = \frac{1}{3} \cdot \sqrt{(\sigma_1 - \sigma_2)^2 + (\sigma_1 - \sigma_3)^2 + (\sigma_2 - \sigma_3)^2} \quad (6-3)$$

$\sigma_1, \sigma_2, \sigma_3$ = major, intermediate and minor principal stresses

Table 6-2. Regression Parameters and R^2 Values for the 2002 Design Guide Stress-Dependent M_R Model

Material	n	k_1	k_2	k_3	R^2
Condon_Base	15	1,235	0.548	-0.497	0.90
Condon_Subgrade	15	1,568	1.007	-1.689	0.97
Deerlodge_Base	15	995	0.655	-0.533	0.89
Deerlodge_Subgrade	15	1,134	0.346	0.128	0.81
Ft Belknap_Base	15	928	0.671	-0.326	0.99
Ft Belknap_Subgrade	15	632	0.450	0.926	0.94
Geyser_Base	15	1,172	0.599	-0.474	0.96
Geyser_Subgrade	15	1,911	0.433	-0.317	0.96
Hammond_Base	15	896	0.586	-0.204	0.98
Hammond_Subgrade	13	2,669	0.764	-3.796	0.84
Lavina_Subgrade	14	1,825	1.130	-2.659	0.94
Perma_Base	15	803	0.565	-0.871	0.88
Perma_Subgrade	15	1,435	0.555	-2.539	0.94
Roundup_Subgrade	15	1,350	0.455	-1.160	0.93
Silver City_Base	15	1,091	0.648	-0.363	0.99
Silver City_Subgrade	15	1,548	0.491	-2.087	0.96
Wolf Pt_Subgrade	12	1,765	0.332	-1.000	0.71

HMA Cores (Subcontractor – Advanced Asphalt Technologies, Sterling, VA): All testing has been completed. There were two objectives for testing the HMA cores. The first was to obtain data for the Superpave Thermal Fracture analysis. This required low temperature creep and strength data at three temperatures. The second objective was to obtain resilient modulus data to compare with stiffness values obtained from the “Witczak et al.” dynamic modulus predictive equation.

Three cores for each material were selected for low temperature creep testing. Each core was tested at three temperatures: -20°C (-4°F), -10°C (14°F), 0°C (32°F). Similarly, for resilient

modulus, three cores were tested for each material, each core at three temperatures: 4°C (39.2°F), 16°C (60.8°F) and 14°C (80.6°F). Indirect tensile strength and strain to failure were obtained at the 6 temperatures used in the M_R and creep tests using 2 specimens per temperature (12 cores per material).

Resilient modulus test results are summarized in Table 6-3 for HMA materials. Indirect tensile strength and strain at failure at 4, 16 and 27°C are summarized for all materials in Table 6-4. In Appendix A, the creep compliance data generated in the low temperature creep tests is summarized in 10 tables corresponding to the 10 materials tested. Although the low temperature indirect strength test data is available, deriving the indirect tensile strength values from the raw test data is a rather complicated and time-consuming process. The results will be included in a later monthly report, as soon as they are available.

Table 6-3. Resilient Modulus Test Results for HMA Materials

SITE	FILE	AAT ID	BRE ID	AIR VOIDS %	TOTAL RESILIENT MODULUS, PSI @		
					4C	16C	27C
SILVER CITY	1	894.10	S279 C3	1.8	1,384,643	532,629	212,188
	2	894.80	S279 C10	4.3	2,195,451	774,476	364,934
	3	894.10	S279 C12	3.3	2,108,077	694,071	299,199
BECKHILL	4	893.70	I-90, C9	4.5	1,271,269	447,588	175,247
	5	893.80	I-90, C10	5.0	1,394,410	562,723	173,096
	6	893.12	I-90, C14	5.7	1,195,527	474,817	226,890
PERMA	7	901.10	S382 C3	6.4	1,376,800	635,967	298,317
	8	901.60	S382 C8	4.4	1,143,651	563,057	269,786
	9	901.11	S382 C13	2.1	2,008,643	606,427	245,682
CONDON	10	892.10	P-83 C3	4.6	1,441,170	638,715	241,611
	11	892.60	P-83 C8	2.6	1,413,412	543,830	242,329
	12	892.11	P-83 C13	0.8	1,531,292	627,328	292,879
HAMMOND	13	900.30	P23 C5	1.2	2,314,013	1,044,821	366,787
	14	900.50	P23 C7	2.4	1,538,330	719,903	311,703
	15	900.11	P23 C13	2.0	1,980,359	983,047	466,999
WOLF POINT	16	897.40	P25 C6	2.7	2,022,975	777,772	304,665
	17	897.80	P25 C10	1.4	1,701,050	588,414	183,888
	18	897.10	P25 C12	2.0	2,088,207	607,834	234,740
FORT BELKNAP	19	898.50	P1 C7	3.1	2,140,623	841,418	413,866
	20	898.90	P1 C11	4.6	1,550,277	699,907	296,021
	21	898.11	P1 C13	2.0	2,616,409	779,747	360,723
ROUNDUP	22	895.20	N/P14 C4	1.9	2,317,975	1,164,792	506,397
	23	895.80	N/P14 C10	2.7	2,451,955	1,233,779	551,238
	24	895.12	N/P14 C14	3.8	3,414,683	1,122,490	581,652
LAVINA	25	896.30	N/P14L C5	2.9	2,328,902	1,037,491	562,907
	26	896.60	N/P14L C8	1.6	1,688,492	1,007,176	582,770
	27	896.12	N/P14L C14	2.4	2,103,453	1,130,575	953,164
GEYSER	28	899.10	P57 C3	3.8	1,611,725	595,763	307,863
	29	899.90	P57 C11	6.6	1,129,466	443,919	188,168
	30	899.10	P57 C12	5.3	2,118,521	426,015	197,769

Table 6-4. Indirect Tensile Strength and Strain at Failure for HMA Materials

MATERIAL	REP	ID	AIR VOIDS %	TEMP. °C	TENSILE STRENGTH PSI	STRAIN AT FAILURE in/in
SILVERCITY	1	S279 C10	4.3	4	482	0.0044
	2	S279 C3	1.8	4	465	0.0035
	1	S279 C7	2.1	16	147	0.0090
	2	S279 C13	3.4	16	196	0.0062
	1	S279 C4	2.2	27	62	0.0112
	2	S279 C12	3.3	27	85	0.0101
	1	I-90, C9	4.5	4	446	0.0045
	2	I-90, C14	5.7	4	430	0.0043
BECKHILL	1	I-90, C6	4.6	16	204	0.0074
	2	I-90, C12	5.3	16	191	0.0078
	1	I-90, C5	4.7	27	92	0.0143
	2	I-90, C10	5.0	27	93	0.0129
	1	S382 C3	6.4	4	450	0.0038
PERMA	2	S382 C13	2.1	4	535	0.0036
	1	S382 C6	4.0	16	197	0.0103
	2	S382 C7	3.6	16	202	0.0093
	1	S382 C8	4.4	27	94	0.0113
	2	S382 C9	3.3	27	86	0.0125
CONDON	1	P-83 C3	4.6	4	410	0.0034
	2	P-83 C12	0.8	4	424	0.0057
	1	P-83 C6	3.7	16	144	0.0078
	2	P-83 C13	0.8	16	160	0.0058
	1	P-83 C8	2.6	27	84	0.0096
HAMMOND	2	P-83 C10	1.7	27	84	0.0131
	1	P23 C5	1.2	4	543	0.0034
	2	P23 C7	2.4	4	554	0.0025
	1	P23 C3	1.4	16	235	0.0042
	2	P23 C6	2.1	16	216	0.0052
WOLF POINT	1	P23 C11	1.6	27	88	0.0080
	2	P23 C13	2.0	27	123	0.0065
	1	P25 C6	2.7	4	483	0.0026
	2	P25 C10	1.4	4	528	0.0042
	1	P25 C8	1.4	16	151	0.0081
FORT BELKNAP	2	P25 C11	1.7	16	151	0.0104
	1	P25 C3	1.8	27	65	0.0160
	2	P25 C12	2.0	27	68	0.0116
	1	P1 C11	4.6	4	389	0.0029
	2	P1 C13	2.0	4	488	0.0033
	1	P1 C3	2.8	16	153	0.0085
	2	P1 C9	4.4	16	144	0.0090
	1	P1 C5	2.8	27	58	0.0127
	2	P1 C7	3.1	27	95	0.0104

Table 6-4. Indirect Tensile Strength and Strain at Failure for HMA Materials, Continued

MATERIAL	REP	ID	AIR VOIDS %	TEMP. °C	TENSILE STRENGTH PSI	STRAIN AT FAILURE in/in
ROUNDUP	1	N/P 14 C4	1.9	4	508	0.0036
	2	N/P 14 C14	3.8	4	461	0.0032
	1	N/P 14 C6	3.4	16	210	0.0061
	2	N/P 14 C9	2.6	16	235	0.0038
	1	N/P 14 C10	2.7	27	117	0.0057
	2	N/P 14 C11	3.2	27	101	0.0190
LAVINA	1	N/P 14L C5	2.9	4	414	0.0043
	2	N/P 14L C8	1.6	4	464	0.0046
	1	N/P 14L C11	2.3	16	210	0.0124
	2	N/P 14L C13	2.6	16	236	0.0053
	1	N/P 14L C4	2.5	27	116	0.0146
GEYSER	2	N/P 14L C14	2.4	27	141	0.0064
	1	P57 C3	3.8	4	458	0.0055
	2	P57 C10	6.3	4	337	0.0057
	1	P57 C8	4.7	16	157	0.0082
	2	P57 C10	6.3	16	145	0.0098
	1	P57 C7	5.5	27	76	0.0128
	2	P57 C12	5.3	27	80	0.0132

CTB Cores (Subcontractors – Fugro South, Inc. Houston, TX; Texas Transportation Institute, College Station, TX): The objective for testing the CTB cores was to obtain the elastic modulus of the material. However, the test protocol (ASTM C 469 - 94) requires 4 in. diameter by 8 in. length test cylinders to be used as test specimens. Cores more than 8 in. in length have been sent to the Fugro-South laboratory in Houston for coring and testing. Difficulties with coring from 6 in. diameter cores were still encountered and are due to insufficient binder content. However, these problems occurred only on 4 of the 15 cores sent to Houston. CTB cores with less than 8 in. lengths have been sent to the Texas Transportation Institute (TTI) Laboratory to be tested for indirect tensile strength and strain at failure. The indirect tensile strength can then be used to estimate the elastic modulus of the material, and it has the advantage that the test specimens are only 1 to 3 in. thick (6 in diameter). The specimens will be obtained by sawing the CTB cores that are less than 8 in. long. In order to check the correlation between the elastic modulus measured at the Fugro laboratory and the indirect tensile strength measured at the TTI laboratory, available cores for the Roundup, Hammond, and Wolf Point CTB materials were sent to both labs.

Although not included in the initial testing plan, density tests will be performed on all CTB materials at the TTI laboratory. Density is a necessary input for any pavement response model and will be useful for the proper characterization of the Montana CTB materials.

A summary of the CTB testing under way is presented in Table 6-5.

Table 6-5. CTB Testing Under Way

Site	No. of Cores	Test Assignments			Laboratory
		Elastic Modulus	Indirect Strength	Density	
ROUNDUP	3	✓	·		Houston
	3	·	✓	✓	TTI
HAMMOND	3	✓	·		Houston
	3	·	✓	✓	TTI
GEYSER	4	✓	·	✓	Houston
WOLF POINT	4	✓	·		Houston
	3	·	✓	✓	TTI
PERMA	3	·	✓	✓	TTI
LAVINA	3	·	✓	✓	TTI
FT. BELKNAP	3		Too Thin	✓	TTI

Testing is almost complete at the Fugro-South laboratory in Houston and just started at the TTI laboratory. The next monthly report will contain the results from Houston and a summary of the progress at TTI.

Backcalculation of Deflections: The first round of deflection tests have been backcalculated and summarized. In addition, the second round of deflection testing has also been backcalculated utilizing the same pavement structure information as the Round 1 data. Using the backcalculated modulus values, the pavement structure was modeled as a linear elastic layered structure in ELSYM 5 and the states of stress in each layer were estimated under a load of equal magnitude with the one used by the Falling Weight Deflectometer (i.e., 9,000 lbf.). For unbound materials, the resilient modulus at the estimated states of stress was predicted using Equation 6-1 and the k_i values in Table 6-2. These laboratory-derived values are compared with the FWD derived values in Figures 6-1 and 6-2 for base materials and respective subgrades. It should be noted that further analysis of these comparisons will be completed for the Task 7 calibration.

For the surface layer, the lab-measured resilient modulus values were used to develop a predictive model for resilient modulus as a function of air voids and temperature. The model is fairly accurate, with a coefficient of determination R^2 of 0.84 and is presented in Equation 6-4:

$$M_R = 10^{6.510 - 0.033T - 0.040V_a} \quad (6-4)$$

Where:

- M_R = Resilient modulus (psi)
- T = Temperature ($^{\circ}$ F)
- V_a = Air voids (% by volume)

Figures 6-3 and 6-4 show a comparison of FWD backcalculated moduli with laboratory measured M_R for all HMA materials, where Equation 2 was used to predict the lab M_R value at

the temperature at which the FWD measurements were taken. Figure 6-3 is representative for the Round 1 FWD measurement while Figure 6-4 uses the results of Round 2.

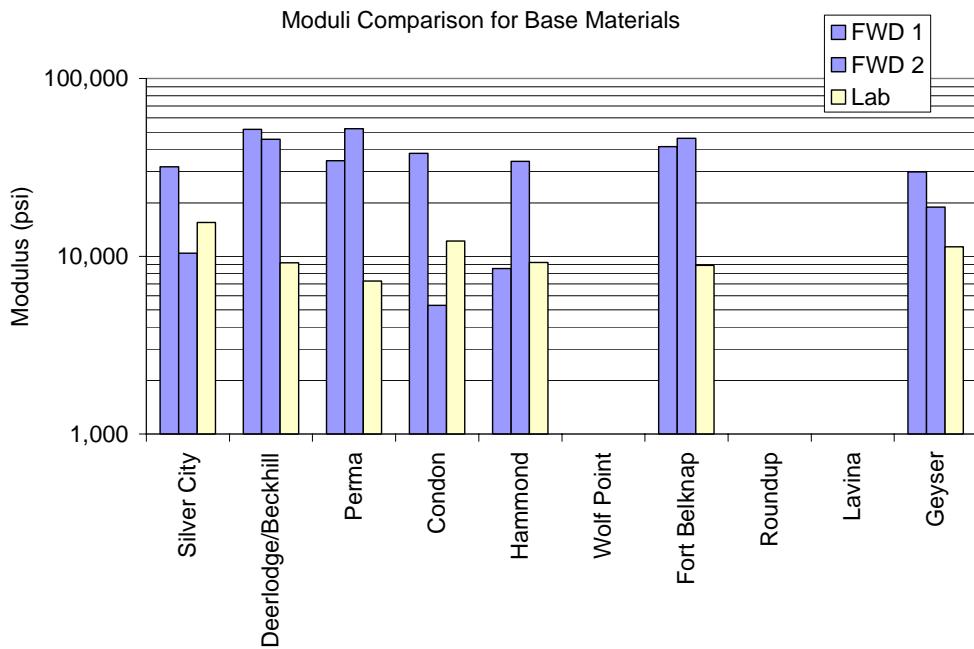


Figure 6-1. FWD values vs. laboratory-derived M_R values for base materials.

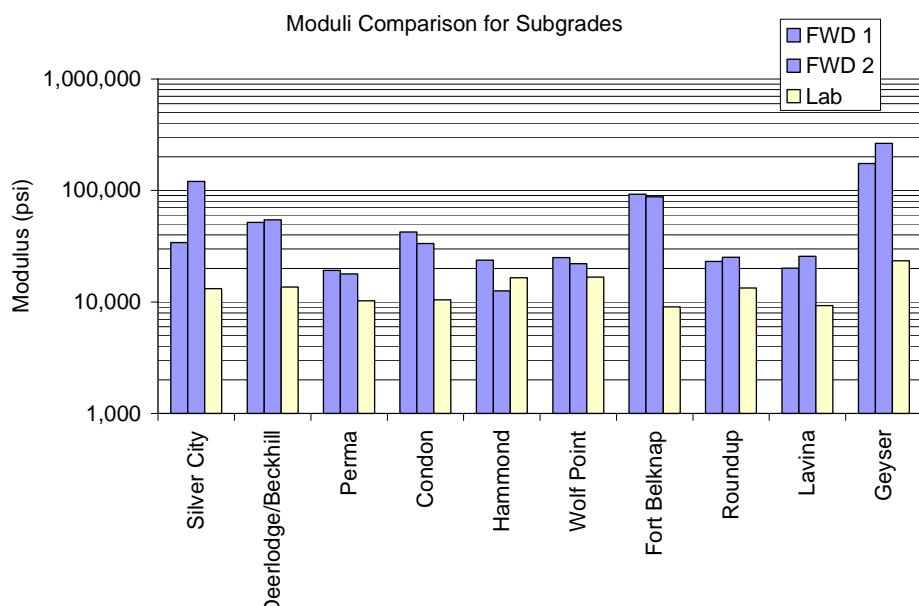


Figure 6-2. FWD values vs. laboratory-derived M_R values for subgrades.

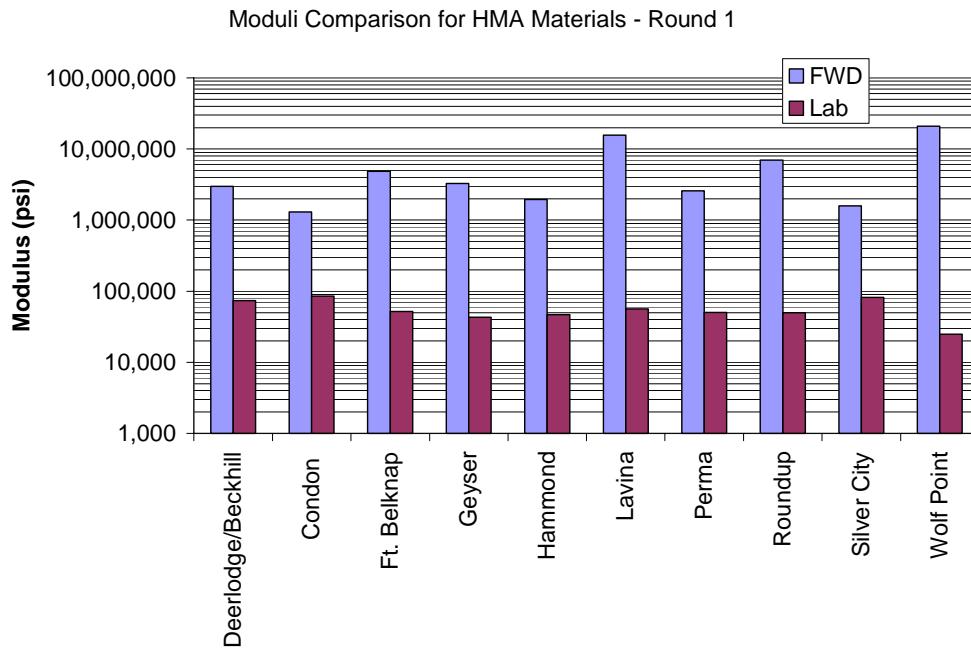


Figure 6-3. FWD values vs. laboratory-derived M_R values for HMA materials – Round 1.

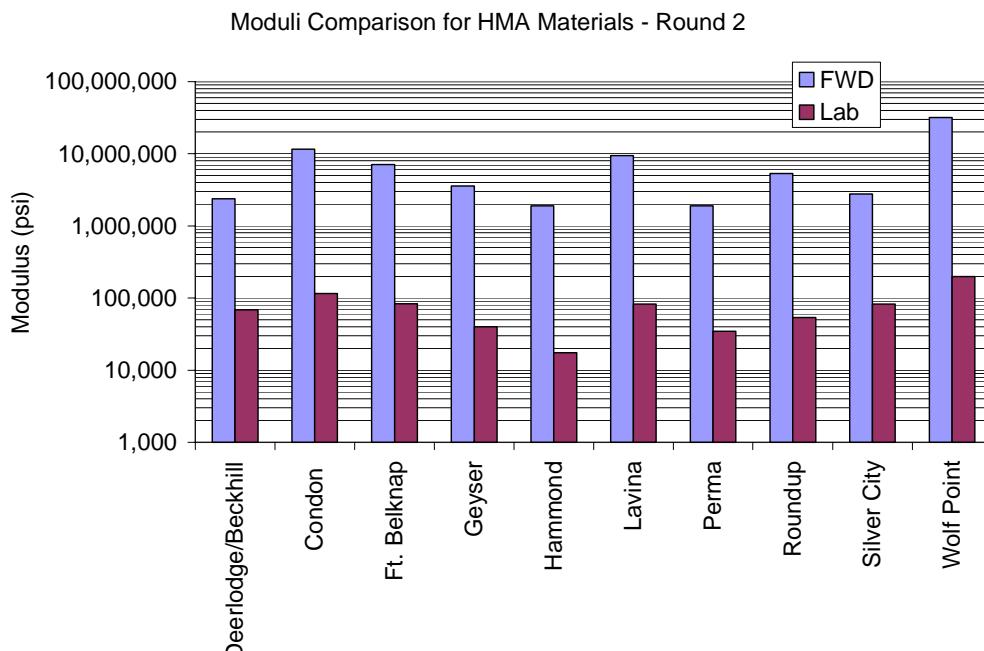


Figure 6-4. FWD values vs. laboratory-derived M_R values for HMA materials – Round 2.

Superpave Supplemental Sites: The project team has received samples from sites constructed with Superpave-designed hot mix and sampled by MDT during the time of construction. The purpose of adding these sections will be to incorporate pavements constructed with current MDT mixture design procedures. An inventory of the materials received to date is included in Table 6-6. A testing plan will be developed once the testing for the initial 10 sites has been completed.

Table 6-6. Summary of Montana Materials Received April 8, 2003.

Site	Pallet	Container	Quantity	Description	C	Identification
Fort Belknap	1	box	6	1 qt cans	binder	NHI 7(32)429 RP 442
		box	16	1 qt cans	binder	NHI 7(32)429 RP 443
		box	2	4" cores	AC	28, 28A; NHI 7(32)429, Hwy P-1; RP 441.7
			2	4" cores	AC	29, 29A; NHI 7(32)429, Hwy P-1; RP 442.1
			2	6" cores	AC	27, 27A; NHI 7(32)429, Hwy P-1; RP 441.1
		bucket	6	5 gallon bucket	Grade S Aggregate	NHI 7(32)429,RP 441.2
		bag	6	70 lb cloth bag	PMS (bulk AC mix)	NHI 7(32)429,RP 437
Vaughn N.	2	box	4	1 qt cans	binder	IM 15-5(98)291; 454+50
			2	1 pt cans	binder	IM 15-5(98)291; 454+50
		box	6	1 qt cans	binder	IM 15-5(98)291; 454+50
					geotextile; placed on the prepared subgrade and covered with subbase material	
		box	1	piece (9 sft)		IM 15-5(100)291; 454+50
			8	1 pt cans	binder	IM 15-5(100)291; 454+50
			2	6" cores	AC	128, 128A IM 15-5(100)291; Hwy I-15; 454
			1	cloth bag	CBC both lifts; Base Course GR SA	IM 15-5(100)291; 454+50
		bucket	6	5 gallon bucket	Grade S Aggregate	IM 15-5(100)291; 454+50
		bucket	1	5 gallon bucket	Subgrade	IM 15-5(100)291; 454+50
		bucket	1	5 gallon bucket	Subbase 50/50	IM 15-5(100)291; 454+50
		3	bag	6	cloth bags	PMS (bulk AC mix)
Lothair E.	1	bucket	1	5 gallon bucket	Special Borrow (looks like subgrade material, wet sand)	NHI 5(6)308; 53+50
		bucket	1	5 gallon bucket	CBC Gr. 5A Lift 1 of 2 (looks like wet, sand+ round gravel, base material)	NHI 5(5)308; 53+50
	2	bag	1	cloth bag	CBC Lift 2 of 2 (coarse gravel no fines)	NHI 5(5)308
		bag	1	cloth bag	CTS Lift 1 of 1 (Crushed Top Surfacing; fine gravel no sand or fines)	NHI 5(5)308
Baum Rd.	3	bucket	1	5 gallon bucket	Subgrade	NHI 5(5)308; 53+50
		bag	1	cloth bags	CBC 1st lift	NH8-4(22)58
		bag	1	cloth bags	CBC 2nd lift	NH8-4(22)58
		bag	1	cloth bags	CBC 3rd lift	NH8-4(22)58
		bucket	1	5 gallon bucket	Subgrade	NH8-4(22)58

Field Investigation Report: A field investigation report has been completed by the project team and includes a summary of the distress surveys, field sampling results (cores, bores, and other geotechnical information), FWD Deflections (Round 1 only), and longitudinal profiles from each of the supplemental sites.

Supplemental Data: Fugro-BRE contacted Dr. Vince Janoo and obtained a copy of the seasonal data and draft report entitled "Performance of Montana Highway Pavements During Spring Thaw." This data will be used in analyzing the response and performance data that were monitored and obtained from other test sections.

Task 7 – Data Analyses and Calibration of Performance Prediction Models

The objectives of this task are to demonstrate the calibration technique required to develop and maintain the various model calibration coefficients that will be used by the department both now and in the future. As discussed with the MDT, four major distress types were considered in the experimental plan and thus require prediction models and calibration coefficients. These include fatigue cracking (both surface initiated and bottom initiated surface cracks), thermal cracking, rutting or permanent deformation, and ride quality.

The project team is currently awaiting release of the AASHTO 2002 Design Guide information, which is expected in the first half of 2003 before attempting any calibration of these models. However, the calibration technique (or the specific steps required to determine calibration coefficients) can still be demonstrated to MDT utilizing models similar in nature to the AASHTO 2002 Design Guide models. The project team is moving ahead with this demonstration portion of Task 7 with data obtained from the LTPP database and the supplemental sites.

The project team has met with Mr. Harold Von Quintus on several occasions and is working on completing the initial calibration effort. Issues discussed at these meetings include the supplemental site testing, model selection, LTPP data gathering, database population, traffic data summarization and environmental data gathering. The following discusses these items separately.

Calibration Database Development: The initial steps required to populate the calibration and validation database have begun. The first step taken was to verify which LTPP data were missing since the last time it was checked. No significant changes in the available data were found.

Also, the status of the additional LTPP sections outside of, but adjacent to, Montana was verified. Each section was checked for sufficient data so that only those sections with adequate data are being utilized.

In addition, Structured Query Language (SQL) statements are being developed for extracting the data required for model calibration from the LTPP IMS. These SQL statements will be provided to MDT so that future calibration efforts utilizing updated LTPP data may be streamlined.

A meeting was held with the database developer wherein specific requirements for the database were discussed. The database developer also relayed information to the PI regarding making the database user-friendly and structured in a way in which the MDT could use the database for further model calibration once this contract is complete. The database schema has been completed, reviewed, and checked, and population of the database has commenced.

Environmental Data: Montana climatic data will be utilized in the calibration effort. Specifically, the AASHTO 2002 environmental database will be used, which will include information for Montana and surrounding regions. However, it is also recommended that MDT include additional years of environmental data (up to 20 years) to better quantify the expected environmental conditions. The project team is incorporating tables into the calibration database

to handle environmental data. This data will include rainfall and temperature information as well as in-situ moisture information for the appropriate environmental zones delineated in the State.

Traffic Data: A review of all the LTPP traffic tables has been initiated. The completeness of the data will be documented and the need for additional traffic information will be assessed. Recommendations for the required traffic information have already been discussed among the project team, Mr. Von Quintus, and Dr. Mark Hallenbeck will continue gathering, reviewing and assessing this data, especially in light of the initial calibration effort currently underway.

Task 8 – Final Report and Presentation of Results

No activity.

PROBLEMS / RECOMMENDED SOLUTIONS

No problems were encountered during last month and none are anticipated next month.

NEXT MONTH'S WORK PLAN

The activities planned for next month are discussed below:

- Coordinate with MDT personnel on an as-needed basis.
- Continue testing materials that are outstanding.
- Continue analysis of all data collected at the LTPP and non-LTPP test sections.
- Continue with the initial calibration demonstration effort.

FINANCIAL STATUS

The Financial Summary I table shows the estimated expenses incurred during the reporting period.

The Financial Summary II table provides the total project expenditures by the Montana and FHWA fiscal years in comparison to the allocated funds for each fiscal year.

The Financial Summary III chart illustrates total expenditures by month for the project.

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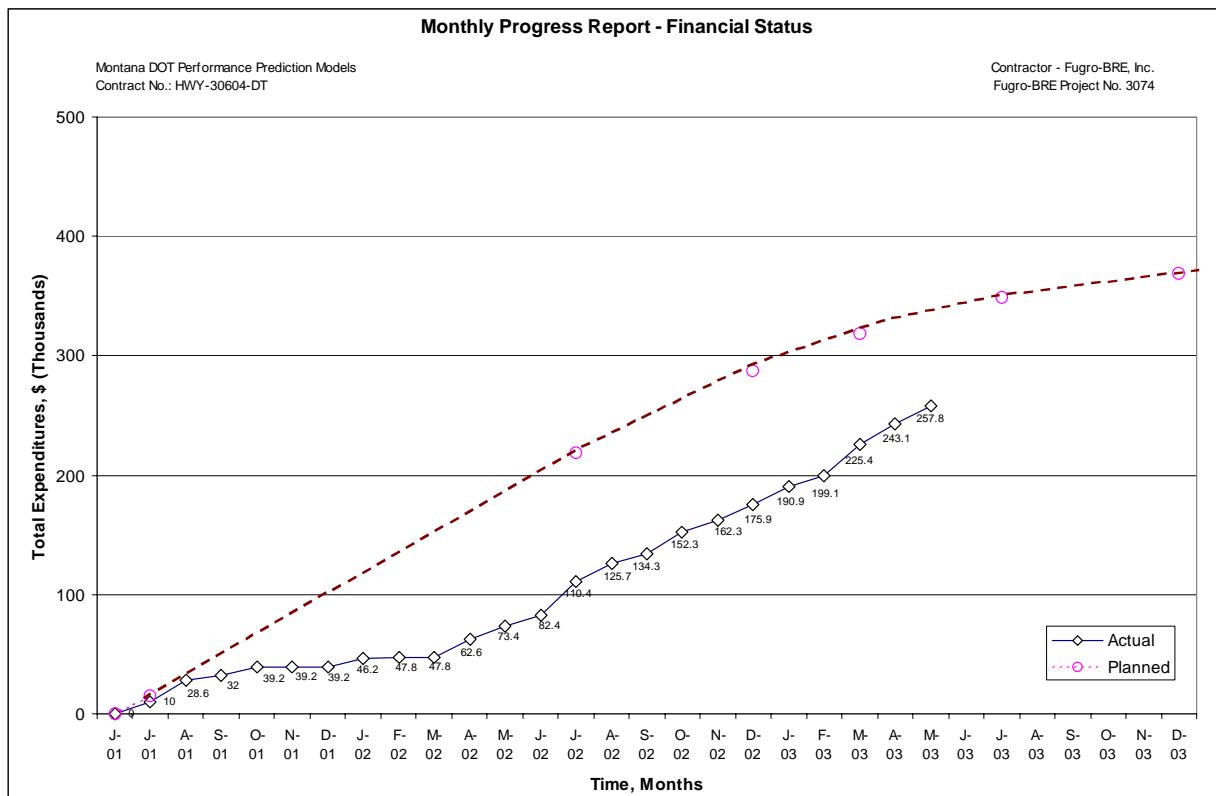
Financial Summary I
Estimated Expenses for Reporting Period: Fugro-BRE

Cost Element	Cumulative Cost Jun 2001 - May 2003, \$	Current Expenditures Apr-May 2003, \$	Cumulative Costs Jun 2001 - May 2003, \$
Direct Labor	48,002	6,318	54,320
Overhead	68,643	9,035	77,678
Consultants/Subcontractors	7,615		7,615
ERES/ARA	10,490	4,313	14,803
Parsons-Brinkerhoff	12,093	0	12,093
SME	523	0	523
Dr. Matthew Witczak	0	0	0
Dr. Mark Hallenbeck	3,130	0	3,130
Travel	10,802	25	10,827
Testing	22,849	5,490	52,958
Other Direct Costs	3,132	856	3,988
Fee	20,499	0	23,437
TOTAL	225,488	32,320	257,808

Financial Summary II
Total Expenditures by Fiscal Year: Montana and FHWA

Montana DOT Fiscal Year			FHWA Fiscal Year		
Fiscal Year	Allocated Funds Cumulative, \$	Expenditures Cumulative, \$	Fiscal Year	Allocated Funds Cumulative, \$	Expenditures Cumulative, \$
6/1-6/30 2001	15,000	*0	6/1-9/30 2001	65,000	31,996
7/1-6/30 2002	218,969	82,420	10/1-9/30 2002	258,969	102,303
7/1-6/30 2003	348,969	175,388	10/1-9/30 2003	358,969	123,509
7/1-6/30 2004	388,969	---	10/1-9/30 2004	398,969	---
7/1-6/30 2005	428,969	---	10/1-9/30 2005	438,969	---
7/1-6/30 2006	498,969	---	10/1-9/30 2006	498,969	---
TOTAL	498,969	257,808		498,969	257,808

*June 2001 expenditures were combined with July 2001 expenditures.



Financial Summary III: Total Expenditures By Month

Appendix A

Creep Compliance Test Results for Montana HMA Materials

Site:	CONDON								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	2.87E-07	0.129	0.149	5.61E-07	0.246	0.413	8.56E-07	0.320	0.413
13	2.95E-07	0.130	0.149	6.04E-07	0.252	0.413	9.46E-07	0.331	0.413
16	3.02E-07	0.131	0.149	6.37E-07	0.257	0.413	9.96E-07	0.339	0.413
20	3.11E-07	0.131	0.149	6.70E-07	0.263	0.413	1.09E-06	0.347	0.413
25	3.18E-07	0.132	0.149	7.17E-07	0.268	0.413	1.18E-06	0.356	0.413
32	3.34E-07	0.133	0.149	7.59E-07	0.274	0.413	1.28E-06	0.366	0.413
40	3.46E-07	0.133	0.149	8.11E-07	0.279	0.413	1.38E-06	0.375	0.413
50	3.58E-07	0.134	0.149	8.68E-07	0.285	0.413	1.51E-06	0.383	0.413
63	3.72E-07	0.134	0.149	9.34E-07	0.290	0.413	1.66E-06	0.392	0.413
79	3.84E-07	0.135	0.149	1.00E-06	0.296	0.413	1.82E-06	0.401	0.413
100	3.89E-07	0.136	0.149	1.05E-06	0.301	0.413	1.98E-06	0.410	0.413
Site:	DEERLODGE/BECKHILL								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	3.34E-07	0.104	0.220	5.40E-07	0.201	0.294	1.20E-06	0.355	0.294
13	3.45E-07	0.104	0.220	5.75E-07	0.208	0.294	1.33E-06	0.368	0.294
16	3.51E-07	0.103	0.220	6.02E-07	0.214	0.294	1.45E-06	0.377	0.294
20	3.59E-07	0.103	0.220	6.19E-07	0.221	0.294	1.54E-06	0.388	0.294
25	3.68E-07	0.102	0.220	6.37E-07	0.227	0.294	1.70E-06	0.398	0.294
32	3.76E-07	0.101	0.220	6.95E-07	0.234	0.294	1.88E-06	0.410	0.294
40	3.91E-07	0.101	0.220	7.39E-07	0.241	0.294	2.06E-06	0.421	0.294
50	4.02E-07	0.100	0.220	7.83E-07	0.247	0.294	2.28E-06	0.431	0.294
63	4.10E-07	0.100	0.220	8.32E-07	0.254	0.294	2.53E-06	0.442	0.294
79	4.22E-07	0.099	0.220	8.89E-07	0.261	0.294	2.82E-06	0.453	0.294
100	4.22E-07	0.099	0.220	9.25E-07	0.267	0.294	3.09E-06	0.464	0.294
Site:	SILVER CITY								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	2.94E-07	0.156	0.217	4.88E-07	0.186	0.223	1.13E-06	0.337	0.223
13	3.02E-07	0.146	0.217	5.02E-07	0.195	0.223	1.23E-06	0.349	0.223
16	3.14E-07	0.139	0.217	5.25E-07	0.202	0.223	1.32E-06	0.359	0.223
20	3.22E-07	0.131	0.217	5.61E-07	0.210	0.223	1.42E-06	0.369	0.223
25	3.30E-07	0.123	0.217	5.89E-07	0.218	0.223	1.55E-06	0.379	0.223
32	3.44E-07	0.114	0.217	6.21E-07	0.226	0.223	1.73E-06	0.390	0.223
40	3.55E-07	0.106	0.217	6.57E-07	0.234	0.223	1.87E-06	0.401	0.223
50	3.61E-07	0.098	0.217	6.94E-07	0.242	0.223	2.09E-06	0.411	0.223
63	3.69E-07	0.090	0.217	7.35E-07	0.250	0.223	2.29E-06	0.421	0.223
79	3.86E-07	0.082	0.217	7.85E-07	0.257	0.223	2.54E-06	0.432	0.223
100	3.83E-07	0.074	0.217	8.22E-07	0.266	0.223	2.78E-06	0.442	0.223

Site:	ROUNDUP								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	2.46E-07	0.094	0.204	3.89E-07	0.195	0.268	7.44E-07	0.299	0.268
13	2.55E-07	0.098	0.204	4.09E-07	0.203	0.268	8.04E-07	0.321	0.268
16	2.58E-07	0.102	0.204	4.36E-07	0.210	0.268	8.57E-07	0.339	0.268
20	2.65E-07	0.105	0.204	4.52E-07	0.218	0.268	9.32E-07	0.358	0.268
25	2.69E-07	0.108	0.204	4.76E-07	0.225	0.268	1.01E-06	0.377	0.268
32	2.77E-07	0.112	0.204	4.99E-07	0.234	0.268	1.12E-06	0.399	0.268
40	2.85E-07	0.116	0.204	5.19E-07	0.241	0.268	1.22E-06	0.418	0.268
50	2.91E-07	0.119	0.204	5.54E-07	0.248	0.268	1.35E-06	0.437	0.268
63	3.01E-07	0.123	0.204	5.82E-07	0.256	0.268	1.49E-06	0.457	0.268
79	3.09E-07	0.126	0.204	6.25E-07	0.264	0.268	1.66E-06	0.476	0.268
100	3.13E-07	0.130	0.204	6.69E-07	0.272	0.268	1.82E-06	0.497	0.268
Site:	LAVINA								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	3.40E-07	0.107	0.244	4.62E-07	0.134	0.175	9.30E-07	0.333	0.175
13	3.51E-07	0.114	0.244	4.72E-07	0.149	0.175	1.04E-06	0.340	0.175
16	3.61E-07	0.119	0.244	4.95E-07	0.161	0.175	1.10E-06	0.346	0.175
20	3.68E-07	0.125	0.244	5.09E-07	0.173	0.175	1.19E-06	0.352	0.175
25	3.80E-07	0.131	0.244	5.38E-07	0.186	0.175	1.26E-06	0.358	0.175
32	3.91E-07	0.138	0.244	5.61E-07	0.200	0.175	1.40E-06	0.365	0.175
40	4.03E-07	0.143	0.244	5.85E-07	0.213	0.175	1.51E-06	0.371	0.175
50	4.08E-07	0.149	0.244	6.13E-07	0.226	0.175	1.63E-06	0.377	0.175
63	4.27E-07	0.155	0.244	6.60E-07	0.239	0.175	1.79E-06	0.383	0.175
79	4.48E-07	0.161	0.244	6.89E-07	0.252	0.175	1.96E-06	0.389	0.175
100	4.59E-07	0.168	0.244	7.21E-07	0.266	0.175	2.11E-06	0.396	0.175
Site:	WOLF POINT								
Temp., F:	-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)
10	1.97E-07	0.124	0.182	4.10E-07	0.246	0.263	1.25E-06	0.448	0.263
13	1.99E-07	0.132	0.182	4.29E-07	0.261	0.263	1.43E-06	0.463	0.263
16	2.11E-07	0.138	0.182	4.68E-07	0.272	0.263	1.55E-06	0.474	0.263
20	2.14E-07	0.145	0.182	4.83E-07	0.284	0.263	1.74E-06	0.487	0.263
25	2.18E-07	0.151	0.182	5.17E-07	0.297	0.263	1.92E-06	0.500	0.263
32	2.33E-07	0.159	0.182	5.66E-07	0.310	0.263	2.19E-06	0.514	0.263
40	2.40E-07	0.165	0.182	6.05E-07	0.322	0.263	2.46E-06	0.526	0.263
50	2.50E-07	0.172	0.182	6.39E-07	0.335	0.263	2.77E-06	0.539	0.263
63	2.63E-07	0.178	0.182	6.98E-07	0.347	0.263	3.12E-06	0.552	0.263
79	2.72E-07	0.185	0.182	7.66E-07	0.360	0.263	3.57E-06	0.565	0.263
100	2.78E-07	0.192	0.182	8.12E-07	0.373	0.263	3.99E-06	0.578	0.263

Site:		FT. BELKNAP								
Temp., F:		-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	
10	2.53E-07	0.125	0.196	4.38E-07	0.207	0.223	9.23E-07	0.292	0.223	
13	2.57E-07	0.130	0.196	4.61E-07	0.221	0.223	9.84E-07	0.316	0.223	
16	2.67E-07	0.135	0.196	4.83E-07	0.232	0.223	1.08E-06	0.335	0.223	
20	2.78E-07	0.139	0.196	5.24E-07	0.244	0.223	1.16E-06	0.356	0.223	
25	2.84E-07	0.144	0.196	5.47E-07	0.257	0.223	1.24E-06	0.376	0.223	
32	2.96E-07	0.149	0.196	5.78E-07	0.270	0.223	1.38E-06	0.399	0.223	
40	2.98E-07	0.154	0.196	6.19E-07	0.282	0.223	1.53E-06	0.420	0.223	
50	3.11E-07	0.158	0.196	6.51E-07	0.294	0.223	1.68E-06	0.440	0.223	
63	3.23E-07	0.163	0.196	7.05E-07	0.306	0.223	1.84E-06	0.461	0.223	
79	3.42E-07	0.168	0.196	7.55E-07	0.319	0.223	2.05E-06	0.482	0.223	
100	3.67E-07	0.173	0.196	8.00E-07	0.331	0.223	2.23E-06	0.504	0.223	

Site:		PERMA								
Temp., F:		-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	
10	3.04E-07	0.091	0.190	4.81E-07	0.143	0.229	9.02E-07	0.279	0.229	
13	3.18E-07	0.094	0.190	5.06E-07	0.160	0.229	9.77E-07	0.299	0.229	
16	3.21E-07	0.097	0.190	5.22E-07	0.173	0.229	1.04E-06	0.314	0.229	
20	3.31E-07	0.100	0.190	5.47E-07	0.187	0.229	1.12E-06	0.331	0.229	
25	3.33E-07	0.103	0.190	5.83E-07	0.201	0.229	1.20E-06	0.348	0.229	
32	3.40E-07	0.106	0.190	5.93E-07	0.216	0.229	1.31E-06	0.367	0.229	
40	3.55E-07	0.109	0.190	6.23E-07	0.230	0.229	1.45E-06	0.384	0.229	
50	3.62E-07	0.113	0.190	6.53E-07	0.244	0.229	1.58E-06	0.400	0.229	
63	3.72E-07	0.116	0.190	6.99E-07	0.258	0.229	1.72E-06	0.418	0.229	
79	3.77E-07	0.119	0.190	7.40E-07	0.272	0.229	1.89E-06	0.435	0.229	
100	3.75E-07	0.122	0.190	7.85E-07	0.287	0.229	2.02E-06	0.453	0.229	

Site:		GEYSER								
Temp., F:		-4			14			32		
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	
10	4.30E-07	0.086	0.277	7.47E-07	0.195	0.305	1.47E-06	0.342	0.305	
13	4.46E-07	0.102	0.277	7.84E-07	0.210	0.305	1.60E-06	0.353	0.305	
16	4.55E-07	0.115	0.277	8.20E-07	0.221	0.305	1.72E-06	0.363	0.305	
20	4.65E-07	0.128	0.277	8.76E-07	0.234	0.305	1.87E-06	0.372	0.305	
25	4.82E-07	0.142	0.277	9.06E-07	0.247	0.305	2.07E-06	0.382	0.305	
32	4.95E-07	0.157	0.277	9.74E-07	0.261	0.305	2.25E-06	0.393	0.305	
40	5.14E-07	0.170	0.277	1.05E-06	0.274	0.305	2.46E-06	0.403	0.305	
50	5.39E-07	0.184	0.277	1.10E-06	0.286	0.305	2.67E-06	0.413	0.305	
63	5.63E-07	0.198	0.277	1.19E-06	0.299	0.305	2.95E-06	0.423	0.305	
79	5.85E-07	0.212	0.277	1.26E-06	0.312	0.305	3.27E-06	0.433	0.305	
100	6.09E-07	0.226	0.277	1.31E-06	0.326	0.305	3.52E-06	0.444	0.305	

Site: HAMMOND										
Temp., F:	-4	14			32					
Loading Time, s	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	Creep Comp., 1/psi	m(t)	μ(t)	
10	2.54E-07	0.067	0.144	4.20E-07	0.199	0.239	8.72E-07	0.360	0.239	
13	2.60E-07	0.079	0.144	4.37E-07	0.206	0.239	9.52E-07	0.364	0.239	
16	2.63E-07	0.088	0.144	4.53E-07	0.211	0.239	1.03E-06	0.368	0.239	
20	2.72E-07	0.098	0.144	4.77E-07	0.217	0.239	1.11E-06	0.371	0.239	
25	2.78E-07	0.108	0.144	4.98E-07	0.222	0.239	1.19E-06	0.375	0.239	
32	2.83E-07	0.119	0.144	5.39E-07	0.229	0.239	1.34E-06	0.379	0.239	
40	2.89E-07	0.129	0.144	5.59E-07	0.234	0.239	1.44E-06	0.383	0.239	
50	3.01E-07	0.139	0.144	5.91E-07	0.240	0.239	1.59E-06	0.386	0.239	
63	3.07E-07	0.149	0.144	6.29E-07	0.246	0.239	1.73E-06	0.390	0.239	
79	3.21E-07	0.159	0.144	6.70E-07	0.252	0.239	1.90E-06	0.394	0.239	
100	3.35E-07	0.170	0.144	7.03E-07	0.258	0.239	2.04E-06	0.398	0.239	